THE GEOLOGY AND PETROLOGY OF THE GREAT SERPENTINE BELT OF NEW SOUTH WALES.

Part I.

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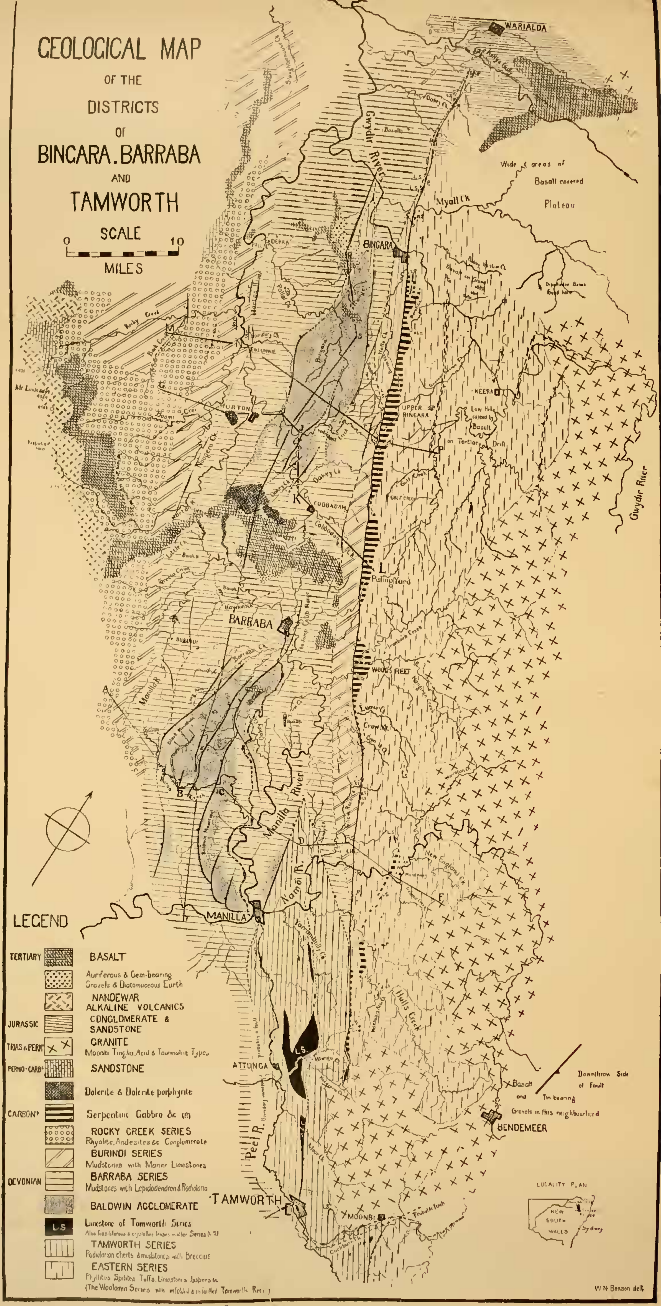
(Plates xx.-xxi.)

Introduction.

The Great Serpentine Belt of New South Wales is one of the most remarkable features to be encountered in the study of the palæozoic geology of the State. Its presence has been known for many years, owing to the association of the serpentine with mineral deposits of economic value, and the outlines of several occurrences were roughly shown in the first official geological map of 1875, based mainly on data collected by the late Rev. W. B. Clarke. Chief among those who have reported on various portions of this belt, have been Messrs. Anderson(**1**), Clarke(**2**), David(**3**) Jaquet(**4**), Odernheimer(**5**), Pittman(**3**), Stonier(**6**), Stutchbury(**7**), and Ulrich(**8**), but lack of opportunity prevented any of these writers from making a detailed study, or attempting any well-founded generalisations. Mr. W. Anderson(**1**) has given the only petrographical account of the ultrabasic rocks (1888), while to Mr. G. A. Stonier(**6**) is due the suggestion of the Upper Carboniferous as the era of the intrusion of these rocks (1895). The tectonic complexity of the associated formations, their great thickness and similarity over wide areas, and also the dearth of determinative fossils, has led to conflicting estimates of their age and relationships, perforcedly based on insufficient data. A great advance was made in 1899, in the recognition, by Professor David and Mr. Pittman, of a great thickness of radiolarian jaspers, cherts and tuffs associated with Middle Devonian coral limestones. Apart from these investigations, the area might be considered virgin ground.


GEOLOGICAL MAP
OF THE
DISTRICTS
OF
BINCARA. BARRABA
AND
TAMWORTH
SCALE
0
10
MILES
WARIALDA
Gwydir River
Wide areas of
Basalt covered
Plateau
Myall Ck
BINGARA
UPPER BINGARA
Low Hills capped by Basalt on Tertiary Drift
HORTON
EULOWRIE
Mt Lindesay
Rocky Creek
Nogero Ck.
COOBADAH
Pulling Yard
BARRABA
WOODS REEF
Crow Mt.
Manilla R.
Manilla River
Namoi R.
MANILLA
New England Ck
Halls Creek
ATTUNGA
Peel R.
TAMWORTH
MOONBI
BENDEMEER
Basalt and Tin bearing Gravels in this neighbourhood
Downthrow Side of Fault
LOCALITY PLAN
NEW SOUTH WALES
Sydney
LEGEND
TERTIARY
BASALT
Auriferous & Gem-bearing Gravels & Diatomaceous Earth
NANDEWAR ALKALINE VOLCANICS
JURASSIC
CONGLOMERATE & SANDSTONE
TRIAS & PERM
GRANITE
Moonbi Tingha Acid & Tourmaline Type
PERMO-CARB
SANDSTONE
Dolerite & Dolerite porphyrite
CARBON
Serpentine Gabbro &c (P)
ROCKY CREEK SERIES
Rhyolite, Andesites &c Conglomerate
BURINDI SERIES
Mudstones with Marine Limestones
DEVONIAN
BARRABA SERIES
Mudstones with Lepidodendron & Radiolaria
BALDWIN AGGLOMERATE
Limestone of Tamworth Series
TAMWORTH SERIES
Radiolarian cherts & mudstones with Breccias
EASTERN SERIES
Phyllites Spilites Tuffs, Limestones Jaspers &c
(The Woolomin Series with infolded & infaulted Tamworth Rocks)
W.N. Benson delt.

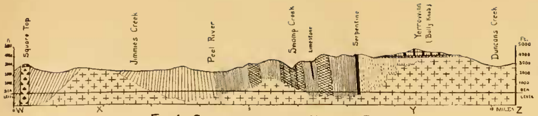
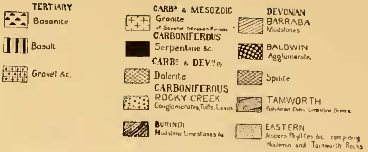


Fig. 1 Section across Nundle District.



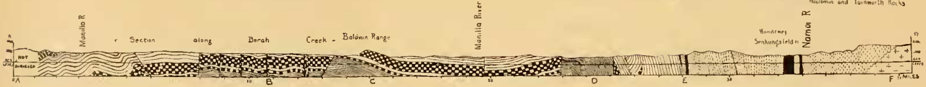


Fig. 2. Section from head of Manilla R to New England Plateau

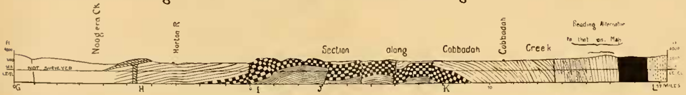


Fig. 3. Section through Horton and Cobbadah

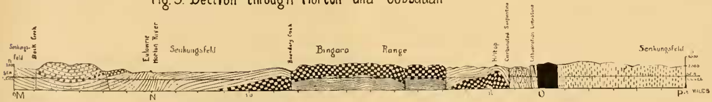


Fig. 4. Section from Back Creek to Keera Senkungsfeld

Fig. 5. Generalised Section from the Gwydir to the Namoi.

particular, the area of the Lower Tuff-breccias is so full of intrusions of dolerite, that it is, in all probability, much disturbed. The uppermost member of this Series, in the Bowling Alley Point district, lies directly below the Nundle Series, the southern equivalent of the Barraba Beds. It is interstratified with thin beds of chert and shale, contains *Lepidodendron australe* and radiolaria, and, in microscopical structure, is very similar to the rock of the Baldwin agglomerate, but more finely granulated. The Upper, Banded Cherts are also interstratified with tuff, showing very peculiar relations with it. Occasionally there are small lenses of limestone, and numerous flows of spilite; one of which is very continuous, and several hundred feet thick in one place. The limestones are intermittently developed, generally in one horizon associated with spilite and breccia. The Lower Cherts and Breccias are similar to those above, but are more free from spilite in the Bowling Alley Point region. It is not yet clear how far the Upper Series is distinct from the Lower Series, or may be a repetition of it.

The section at Tamworth, described by Messrs. David and Pittman, commences at the top of the Lower Breccias, and includes the remainder of the Series. For this, they give a thickness of 9,260 feet, or about the same thickness as the whole of the Bowling Alley Series. The dip, which is very steep at Bowling Alley Point and Tamworth, lessens at Attunga; and the great thickness (1,000 feet or more) reported for the Moor Creek limestone, is probably incorrect. The widening of outcrop is due chiefly to change of dip. The limestones of Tamworth and Moor Creek are really a repetition, by folding and faulting, of the main line of limestone, which passes northwards from Moonbi to the higher part of Attunga Creek. Beyond this, it appears to pass into the eastern side of the serpentine-belt, and may be traced northwards to the latitude of Crow Mountain. Probably the continuous band of limestone, from Bingara to Warialda, belongs to this horizon. The fact that the grey, even medium-grained, andesitic tuff, so common in the Nundle-Barraba Series, is absent from the Tamworth Series in its typical form, is often a useful distinguishing feature.

The following are the fossils found in the several occurrences of limestone; and these have been claimed by Mr. Etheridge(10) as indicating a Middle Devonian age for the Tamworth Series:—

The fossil-localities are grouped as under :—

i. Parishes of Cuerindi and Attunga (fossils determined by W. S. Dun).

ii. Moor Creek and Tamworth (R. Etheridge).

iii. Moonbi (R. Etheridge).

iv. Bowling Alley Point and Nundle (W. S. Dun).

v. Crawney (W. S. Dun).

	i.	ii.	iii.	iv.	v.
Favosites gothlandica Lam., ...	...	x	x	x	x
F. basaltica, var. *moonbiensis* Eth.fil.	...	...	x	...	x
F. salebrosa Goldfuss	...	x	...	x	x
F. squamulifera Eth.fil., ...	...	x	...	...	...
F. multitabulata Eth.fil., ...	...	...	x	x	x
F. sp., cf. *forbesi* Ed. et H., ...	...	x	...	...	...
F.(?) *pittmani* Eth.fil., ...	...	...	x	?	...
F.(?) *crummeri* Eth.fil., ...	...	x	...	..	x
F. reticulata Blainv., ...	..	x	...	...	...
F. sp.nov.	x	...	...	...	...
Stromatopora sp.	...	?	...	x	x
Diphyphyllum porteri Eth.fil., ...	...	x	...	...	x
D. robustum Eth.fil., ...	...	x	...	...	...
D. sp.nov.	...	...	...	...	x
Sanidophyllum davidis Eth.fil., ...	...	x	...	...	x
Tryplasma, sp.nov.	x	...	...	...	x
Spongophyllum giganteum Eth.fil.,	...	x	...	...	x
Actinocystis(?) *cornubovis* Eth.fil.,...	...	x	...	...	x
Cyathophyllum obtortum Ed. et H.,	...	x	...	...	...
C. sp.nov.	x	...	...	...	x
Cystiphyllum australicum(?) ...	...	...	...	...	x
Microplasma parallelum Eth.fil., ...	x	...	...	...	x
Heliolites porosa Goldfuss ...	x	x	...	x	x
Syringopora auloporoides De Kon.,	...	x	...	?	x
S. porteri Eth.fil.	...	x	...	...	...

	i.	ii.	iii.	iv.	v.
S. sp.nov.	x	...	...	...	...
S. novæcambrensis Eth.fil., ..	?	...	...	...	...
Litophyllum konincki Eth.fil., et F.	x	x	...	x	x
L. sp.nov.(?)	x	...	...	...	...
Alveolites subæqualis Ed. et H. ...	...	x	...	...	...
A. sp.	...	x	...	x	x
Phillipsastræa, sp.nov.	x	...	...	x	...
Endophyllum schlüeteri Eth.fil. ...	...	...	...	...	x
Atrypa reticularis var.	...	...	...	...	x
A. sp.	...	...	...	x	...
Pelecypoda indet.	...	...	...	...	x
Euomphalus, sp.nov.	...	...	...	...	x
Crinoid stem-ossicles	x	x	x	x	x
Lepidodendron australe McCoy ...	...	x	...	x	...

The radiolaria, in the Tamworth Beds, were studied by Dr. G. J. Hinde, who described fifty-three species, all of them new, belonging to twenty-nine genera, of which four were new(**11**).

(*c*) The Baldwin Agglomerates lie conformably below the Barraba Series. They are of the same nature as the bands of tuffaceous agglomerate that lie in the latter, and are merely coarser in grain. They consist of fragments or boulders, up to a foot in diameter, of granite, and quartz-porphyry, keratophyres, trachytes, spilites, porphyritic andesites (holocrystalline or pumiceous) augite-diorite porphyrites, quartz-dolerites, radiolarian chert, or cherty tuffs, and fragments of limestone containing determinable fossils: *Heliolites, Syringopora,* and *Stromatopora* have been noted. The pebbles are included in a matrix of andesitic or spilitic, tuffaceous nature. Here and there, they pass into tuffaceous breccias, indistinguishable from those of the Tamworth Series. In the Bingara district, they are interbedded with radiolarian cherts, and contain flows of rapidly chilled, porphyritic spilite of a very basic character. In places, there are lenticles of finer-grained tuff in the coarse agglomerate, and these are of great assistance in determining the true bedding-plane. In a few places, *Lepidodendron aus-*

trale has been found in these rocks. The thickness of this Series is unknown. A thickness of 1,300 feet has been observed in the Baldwin Mountain, and 3,000 feet in Cobbadah Creek Gorge, but even here, the basal beds have not been seen. The especial feature of these beds, physiographically, is their great resistance to erosion, and consequent high relief.

No certainty has yet been arrived at, with regard to the manner in which these beds rest on the underlying Tamworth Series. The only junctions between them, studied so far, are those near Tamworth. These have been claimed by Professor David and Mr. Pittman(3) to show an unconformity of a very marked character, but the observations of the writer, on two of the three junctions, show that it is exceedingly difficulty to obtain a true angle of dip for the agglomerates (so much are they jointed), unless a pebble-band is present; and where this is seen, its dip is parallel to that of the Tamworth Beds directly below it. But, as the Tamworth Beds warp rather rapidly in this region, considerable care must be taken in examining them. The observations will be detailed later. The third area described as an unconformity, the writer unfortunately did not visit, but the evidence of the first two, throws some doubt on this last determination.

The apparently marked, lithological unconformity between the Baldwin Series and the underlying Tamworth radiolarian beds, calls for some remark. An unconformity is brought about by the intervention, between the deposition of two series, of a considerable length of time, during which the conditions have more or less completely altered. The character of the overlying beds has thus no necessary relation to that of the lower beds. Should the deposition, however, have continued while the change of conditions was in progress, and this change have been oscillatory, certain zones interstratified in one series will show indications of the conditions that will be predominant in a higher series, or, conversely, will recall the dominant conditions of lower series. There will be no absolute and sharply defined final break in the character of the sedimentation. Now the Baldwin Agglomerates differ merely in coarseness of grain, from the breccias of the Tamworth Series. The component rock-fragments, and broken mineral-grains are strikingly similar to those of the Tamworth breccia. They are interstratified with similar spilite-flows, and, in several instances, are interbedded with fine radiolarian chert and tuff, almost indistinguishable from the rocks that predominate in the Tamworth Beds. Further, the Barraba Beds, which lie conformably on the Baldwin Beds, exemplify perfectly this lithological criterion of conformity, for they contain interstratified bands of coarse, tuffaceous agglomerate or breccia, quite analogous to that of the Baldwin agglomerate, though not quite so coarse. There is, thus, a complete conformity during oscillatory change of conditions, from the Tamworth Series through the Baldwin Beds to the Barraba Series

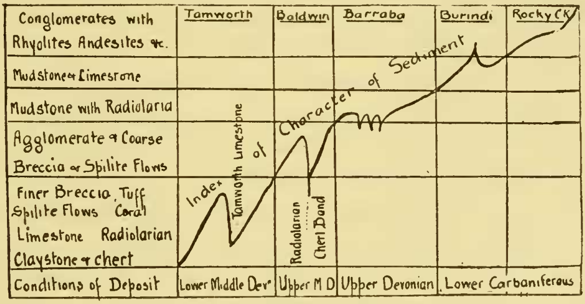


Fig.2.

(text-fig. 2). In the Nundle region, the Baldwin Agglomerates are absent, or represented by a thin band merely, of rather coarse breccia; and, above and below this, the Bowling Alley and Nundle Series lie in perfect conformity with each other. These two Series are identical with the Tamworth and Barraba Beds further north. There seems, then, sufficient grounds for dissenting from the interpretation put on the Tamworth junctions by Messrs. David and Pittman. It should be noted that their conclusion was not a very definite statement, for in the concluding remarks they say, "If the one bed of conglomerate observed near Tamworth be not referable to the Radiolarian series, as appears probable, the whole of the strata are remarkably fine-grained. . . ."

The Baldwin Agglomerates occur in the Bingara Range, rising from below the Barraba Series on the Gwydir River. They continue southwards, bordered by powerful faults on the east and west. Disappearing below the Barraba Beds in the region of Cobbadah and the Manilla River, they rise again to form the Black Mountain and Baldwin Ranges, which are cut off to the west by powerful faults; and dipping to the east, they pass, in a syncline, below the lower Manilla River, and rise again to form Pyramid Hill, above the town of Manilla. From here southwards, they have not been noted, until one comes to the three small occurrences on Cleary's Selection, near Tamworth. Southwards thence, they seem to die out rapidly. They are not seen south of Black Jack, unless the few yards thick, of rather coarse tuff that separates the Bowling Alley from the Nundle Series, may be considered their representative, as its lithology would suggest.

(*c*) The Barraba Series lies conformably above the Baldwin Agglomerates. They are the most wide-spread division of the Palæozoic rocks west of the serpentine-line. They consist of banded shales and mudstones, containing radiolaria, with slightly coarser-grained layers free from these fossils. Interbedded with these, are fine or coarsely grained bands of acid or intermediate tuff, or, rarely, conglomerate bands are present. More frequent, however, are wide or narrow zones of a tuffaceous agglomerate, recalling the Baldwin Agglomerates. In places, there are masses of rocks that might be classed as grauwackes; these are particularly well developed south and east of Cobbadah, and in the Nundle district. There are frequently also large or small lenticles of blue argillaceous limestone, which is quite free from organic remains. Throughout, *Lepidodendron australe* is particularly abundant. Indeed, the distinction between the Barraba Series and the Burindi Series, lies largely in the absence of *L. australe* (and radiolaria) from the latter. Stonier reported *L. australe* to occur with the Carboniferous Marine Beds at Burindi(6), but this is not confirmed by later collections.

As previously stated, these beds form the greater part of the area mapped, and extend far to the west of the serpentine, forming the Liverpool Plains, and the hills between the Peel River and Goonoo Goonoo. Their thickness is doubtless very great, but has not been proved, as nowhere have the top and bottom been seen in one section, nor can due allowance be made for strike-faulting, owing to the absence of horizons of reference. A thickness of about 8,000 feet is apparently developed between the fault east of Burindi and the marine beds to the west, and an apparent thickness of about 13,000 feet occurs between the Peel River and Squaretop by Nundle.

(*d*) The Burindi Series lies conformably above these mudstones, and it has not yet been possible to draw a sharp distinction between them. They consist of a fine, dark grey, fissile mudstone, with bands of tuff of an andesite nature, and occasionally a rather coarsely grained, tuffaceous breccia. Here and there are thin bands of limestone, composed almost entirely of crinoid-ossicles, and other beds largely oolitic. The formations have a very wide extent. They are found in the north, on Slaughterhouse Creek, near Gravesend, and thence, traced southwards, occur to the east of the Rocky Creek Series, all along its development. Just beyond the limits of the area studied, it is very well developd at Somerton, where a considerable thickness of highly fossiliferous limestone was found by Mr. Stonier(6). From information gathered, it would appear to cover a considerable area running north-west of here, appearing from beneath the syncline of Rocky Creek conglomerate that lies west of Burindi. Fossils have been found at Rangira, which probably belong to this Series, but they have not yet come under scientific notice. Further south, there is an extension parallel to the Rocky Creek conglomerates. Marine fossils have been collected near Goonoo Goonoo and Gundy, and are developed in great amount in the Paterson-Clarencetown area, north of Newcastle, as studied by Messrs. J. B. Jaquet and L. F. Harper (12). There are also other areas of development to be considered. Along the western margin of the serpentine, stretching from the head of Hall's Creek to the Namoi River, is a line of similar mudstones and tuffs, which contain Carboniferous fossils. The southernmost occurrence is near the Namoi River, and consists of a lenticle of limestone about 100 yards in length, entirely composed of crinoid-remains, and, except for its greater width, completely analogous to the limestones at Burindi. Further north, at Crow Mountain, there is a series of fossils of the same facies as those of Burindi also. These were first noted by Stonier(6d). North again, however, there is an occurrence of quite a different facies, in the shape of a lenticular mass of limestone, composed chiefly of *Lithostrotion*. These indicate a Carboniferous age for these rocks. It is probable, though not at present capable of proof, that these last are on a rather lower horizon in the Carboniferous, than the Burindi and Crow Mountain fossil-beds.

The mudstones, with oolitic limestones, on Oakey Creek, south of Warialda, probably belong to the Burindi Series also.

These areas adjacent to the serpentine are, without doubt, repetitions of those further west, nipped into the older Barraba rocks during the period of folding.

The following are the determinative fossils that have been recognised in this belt of marine Carboniferous rocks.

In this list, D indicates a determination made by Mr. W. S. Dun, E by Mr. R. Etheridge, Jun., K by Professor De Koninck (in 1875), and S by Mr. S. Stutchbury, in 1853-5. The various localities studied (with the collectors) are as under:—

i. Slaughterhouse Creek ...	Carne.
ii. Pallal and Eulowrie ...	Stutchbury, Cullen, Porter.
iii. Rocky Creek	Pittman.
iv. Burindi	Benson.
v. Crow Mountain... ...	Stonier, Cullen, and Benson.
vi. Somerton, Carroll, etc. ...	Stonier, Cullen, Porter.
vii. Paterson, Clarencetown, and Dungog.	Clarke, Waterhouse, Cullen, and others.

The last area is the most fully studied Carboniferous locality in New South Wales, and is added for the sake of comparison. Only such forms as occur elsewhere, also, have been mentioned, so that, for this locality, the list is incomplete.

	i	ii.	iii.	iv.	v.	vi.	vii.
CŒLENTERATA.							
Cladochonus tenuicollis	...	E	...	D	...	D	K
Cyathophyllum sp.	D	...	...	...	...	...	K
Zaphrentis culleni	...	E	...	D	...	...	E
Z. sumphueus	...	...	...	...	...	E	...
Z., other species	D	...	...	...	D	...	K
Amplexus, sp.ind.	...	E	...	...	...	...	...
Lophophyllum minutum	...	...	...	...	...	..	*K
L., cf. *corniculum*	...	...	...	D	...	...	K
Lithostrotion columnare	...	E‡	...	...	...	...	...
L. irregulare	...	...	...	...	...	...	†K
Turbinolopsis	...	S	...	...	...	...	...
Syringopora syrinx	...	E§	...	...	...	...	...
S. sp.	D	...	...	...	...	‖	K
Michelinia sp	...	D	...	...	...	E	...
Trachypora	...	...	...	...	...	...	D
CRINOIDEA.							
Platycrinus sp.	...	S	...	...	...	...	...
Actinocrinus sp.	...	...	...	...	D	...	D
Cyathocrinus sp.	...	S	...	...	...	...	K
Metablastus	...	...	...	...	...	...	¶
Crinoid ossicles (in all localities) ..	x	x	x	x	x	x	x
BRYOZOA.							
Fenestella propinqua	...	K	...	...	...	...	K
F. multiporata	..	...	...	...	...	...	D
F., other species	D	D	D	D	D	D	K
Thamniscus sp.	...	D	...	...	...	...	...
Dendricopora hardyi	...	K	...	...	...	...	K
Glauconome bipinnata	...	S	...	...	...	...	...
Retepora sp.	...	S	...	...	...	...	...
R. laxa	...	...	...	...	D	...	...
Rhombopora sp.	...	D	...	...	D	...	...
Polypora sp.	...	...	...	...	?D	...	K
Stenopora sp.	..	...	...	...	...	...	D

* From Colo Colo River.

† From Manning River.

‡ Probably also at Hall's Creek.

§ Probably also at Hall's Creek, Lithostrotion limestone.

‖ Possibly *S. novæcambrensis* (Eth.fil.) is of Burindi age, and may occur south of Crow Mountain.

¶ Taylor, T. G., Proc. Linn. Soc. N. S. Wales, 1906, xxxi., p.52.

	i.	ii.	iii.	iv.	v.	vi.	vii.
*BRACHIOPODA.							
Lingula	...	...	...	...	D	...	...
Orbicula sp.	...	S	...	...	...	...	...
Orbiculoidea nitida	...	...	...	...	..	...	D
Productus semireticulatus... ...	...	...	...	D	...	D	K
P. undatus	...	...	...	D	...	...	K
P. barringtonensis	...	...	...	...	...	...	D
P. aculeatus	...	K	...	...	...	...	K
P. cf. *grandicosta*	...	...	...	...	...	...	D
P. cf. *pustulosus*	...	...	...	D	...	...	D
P. cf. *spinulosus*	...	...	...	D	...	...	...
P. cf. *muricatus*	...	...	...	...	...	D	...
P. cf. *murchisoni*	...	...	...	...	...	D	...
P. cf. *longispinus*	...	...	...	...	...	D	D
P., other species	...	D	D	D	D	..	...
Daviesiella sp.(?)	...	...	...	...	D	...	...
Chonetes laguessiana	...	K	...	...	...	...	K
Leptæna (*Strophomena*) *rhomboidalis*, var. *analoga*	...	S	...	D	D	D	D, K
L., other species	D	S	...	...	...	...	...
Orthotetes crenistria	...	..	...	D	D	D	D, K
Orthis (*Schizophoria*) *resupinata* ...	...	S, K	...	D	D	D	D, K
Orthis (*Rhipidomella*) *australis* ...	...	...	D	...	D	D	D, K
Orthis, other species	...	...	...	D	...	...	...
Spirifera disjuncta	...	S	...	...	...	...	...
S. striata	...	...	...	D	...	D	D
S. bisulcata	...	...	...	D	..	...	K
S. lata...	...	...	...	?D	D	...	D
S. humerosa	...	cf. D	...	...	...	D	...
S. pinguis	...	. .	...	...	...	D	D, K
S. convoluta	...	S	...	...	...	...	...
S., other species...	D	D	D	D	...	D	K
Syringothyris exsuperans	...	D	...	...	...	...	D, K
S. cf. *cuspidata*	...	...	...	D	...	...	K
Spiriferina cristata	...	...	...	...	...	...	D
Dielasma hastata	...	K	...	...	...	D	D, K
Rhynchonella sp.	D	...	...	...	...	...	K
R. pleurodon	...	...	...	...	...	...	D
Hypothyris	...	S	...	...	...	...	...
Retzia sp.	...	...	...	D	...	...	...

* For a list of the Brachiopoda of the Clarencetown Series, see Dun, W. S., Records Geol. Survey, N. S. Wales, 1902, vii., pp.72-93, Pls.21-23.

	i.	ii.	iii.	iv.	v.	vi.	vii.
Reticularia lineata	...	...	...	D	...	...	D
Athyris sp.	...	...	...	D	D	...	...
Actinoconchus planosulcatus	...	...	...	D	...	...	E
Atrypa sp.	...	S	...	...	...	...	...
Pelecypoda.							
Allorisma	...	...	...	...	...	...	D
Orthonota sp.	...	S	...	...	...	...	...
Cardinia	...	...	...	...	...	...	D
Nucula sp.	...	S	...	...	...	...	...
Mytilus sp.	...	S	...	...	...	...	...
Posidonia sp.	...	S	...	...	...	...	...
Pteronites(?) *tanipteroides*	...	...	...	...	...	E	...
P. pittmani	...	...	...	...	...	E	...
Pterinea	...	...	...	...	...	...	D
Avicula sp.	...	S	...	...	...	...	K
Pecten sp.	...	S	...	...	...	...	...
Entolium aviculatum	...	...	...	...	...	D	?E
Aviculopecten sp.	...	...	...	...	...	D	K
A. cf. *granulosus*	...	...	...	...	...	...	D
Edmondia sp.	...	...	...	D	...	...	...
Scaphopoda.							
Dentalium sp.	...	...	...	...	...	D	K
Gastropoda.							
Bellerophon sp.	...	S	D	...	...	...	D
Euomphalus sp.	...	S	D	...	...	...	E
Worthenia canaliculata	...	...	...	...	...	E	...
Loxonema sp.	...	S	D	...	...	D	K
L babbindoonensis	...	...	...	...	...	D	...
Macrocheilus sp.	...	S	D	...	...	...	K
Orthonychia, sp.nov.	...	...	D	...	...	...	...
Platyceras altum	...	S,K	...	...	...	...	...
Pteropoda,							
Indefinite species	...	S	D	...	...	...	...
Conularia	...	...	...	...	...	...	D
Cephalopoda.							
Orthoceras sp.	...	S	...	...	...	...	D
O. cf. *martinianum*	...	...	...	...	...	...	D
Trilobita.							
Phillipsia grandis	...	...	...	...	...	E	...
P. dubia	...	...	...	...	...	...	D
Other species	...	S	...	D	D	...	K

Plantæ.—*Lepidodendron australe* has been reported from Burindi and Eulowrie, but is to be very doubtfully referred to the Carboniferous Marine Series.

Lepidodendron veltheimianum has been recorded from Clarencetown (Ann. Rept. Dept. Mines for 1898, p.167).

The thickness of the fossiliferous marine beds, at Burindi, is about 1,000-1,500 feet, but it is not yet possible to define their lower limit. In the Clarencetown area, Messrs. Jaquet and Harper suggested that the Marine Series, volcanics, and conglomerates (equivalent of the Rocky Creek Beds), together amount to 19,000 ft. in thickness(11), but there is probably repetition here.

(*a*) The Rocky Creek Conglomerates form one of the most persistent horizons in New South Wales. They consist of heavy conglomerates containing pebbles of acid igneous rocks, granite, aplites, quartz-porphyries, rhyolites, etc., with trachytes, dacites, and andesites. These conglomerates are interbedded with flows of rhyolite, trachyte or andesite, of a similar nature to that of the pebbles in the conglomerate, together with beds of tuff of the same variety of composition, passing into tuffaceous and gritty sandstones. They occur, in the north, in the Slaughterhouse Creek Ranges, and extend thence south to Rocky Creek, and the eastern slopes of the Nandewar Mountains, pass west of Burindi, and are cut out near the head of the Manilla River. They commence again further to the south, beyond the limits of the map given, and may be followed thence from the south-west of Goonoo Goonoo, past Gundy down into the districts of Gosforth, Paterson, and Clarencetown in the vicinity of Maitland and Newcastle. This intermittent line of outcrop is thus roughly parallel to the serpentine-line, lying from 20-40 miles west of it, and extending for 200 miles. The beds have also a considerable lateral extension to the west, for the intricate series of Carboniferous volcanic rocks, recently described by Messrs. Walkom and Browne(13) at Pokolbin, 50 miles south-west of Newcastle, undoubtedly belong to this series. With the exception of the last rocks, and those developed at Clarencetown, no part of this huge extent of conglomerates and volcanics has been studied in any detail as yet.

The fossil content of this series is small. In the northern portion, near Slaughterhouse Creek, Mr. G. A. Stonier(6c) found some leaf-fragments resembling *Rhacopteris*. In the continuation of these beds down into the Newcastle region, a larger flora is developed, the following being the chief species :—

Calamites (*Archæocalamites*) *radiatus* Feistmantel.
Lepidodendron veltheimianum Feist.
L. volkmannianum Feist.
L. dichotomum Feist.
Knorria Feist.
Cyclostigma australe Feist.; n.s.
C. kiltorkense (?) Feist.
Anemites ovata Arber, Dun, = *Rhacopteris inæquilatera* Feist.
Rhacopteris intermedia Feist., Dun; n.s.
R.(?) *rœmeri* Feist.
R. septentrionalis Feist.; n.s.
Archæopteris wilkinsoni Feist.; n.s.
Cardiopteris polymorpha Dun.
Sphenopteris clarkei Dun; n.s.
Sphenophyllum sp., Feist., = *Anemites*(?) sp., Dun.

In the above list, the names given are those of the palæobotanists who recognised the occurrence of the several species in New South Wales; n.s., indicates that the species was not known elsewhere. Mr. Arber has kindly pointed out to the writer, that all the genera are found in the European Lower Carboniferous, and many of the species are characteristic of that Series. It seems justifiable, therefore, to consider these plant-beds as of Lower Carboniferous age, though they form the upper portion of the Carboniferous Series proper, as developed in Northern New South Wales.

The vertical extent of the Rocky Creek Series is unknown; in the type-locality, a thickness of at least 2,000 feet is exposed.

Such then is the sequence of the older palæozoic sediments. We may now revert to Devonian times, to consider the igneous succession. The spilitic flows and tuffs of the Woolomin and Tamworth Series have already been described. Connected with these, there is a great development of dolerite, often albitised(14). In the preliminary note(15), the writer termed this a diabase, and considered it of later date than the serpentine. The term, however, has been altered, in accordance with modern British nomenclature. The consideration of the age is a different matter. The field-relations in the Nundle region were insufficient to determine, with precision, the position and origin of the rock, and the petrological peculiarity had not been noted. It was thought best to consider it as a later differentiate of the same magma as the serpentine, and, therefore, to be looked for in connection with that rock. At the same time, it did not escape notice, that the dolerite-intrusions ran roughly parallel to the strike, and were confined to the Tamworth (there called Bowling Alley) series of rocks. The later work in the northern district, and the detailed petrology have added much information. Several other distinctive types of dolerite have been found, but that which is analogous to the Nundle dolerite, occurs in rocks of the Tamworth Series only, whether these lie east or west of the serpentine-belt. Where the Tamworth rocks are not developed, the serpentine is quite unaccompanied by dolerites of this character. Moreover, the so-called andesitic lavas in the Tamworth Series, asssociated with the dolerites, prove to be spilites. There are many occurrences cited by Steinmann(16), and Messrs. Dewey and Flett(17), of Ordovician Hercynian, and Alpine eruption-periods, where sediments, usually radiolarian, are associated with tuffs, spilite-flows, and *intrusive sills* of dolerite; and it seems most probable, in view of the later observations, that a like association holds for the rocks under consideration here. In all, these sills are about 2,500 feet thick in the Bowling Alley Point district, but are extremely irregular. The present group of dolerites are then connected with the spilites, not *directly* with the peridotites; and as, in the north, the dolerites have undergone the crushing, in areas east of the serpentine-line, they may fairly be considered to be of earlier date than the serpentine. These dolerite-intrusions were probably almost contemporaneous with the spilite lava-flows, possibly somewhat later.

After the succeeding explosive action that produced the Baldwin Agglomerates, there was a long period of quiet. Then igneous activity broke out again, and the rhyolites, andesites, and tuffs of the Rocky Creek Series were ejected.

The intrusion of the peridolites then followed; they have been shown to occur chiefly in the fault separating the Eastern rocks from the rest of the country, and it is probable that they were intruded into this fault-plane during the crust-movement. They show some signs of shearing in themselves. That the folding period was at the close of the Carboniferous, is indubitable, in view of the strong unconformity between horizontal or slightly disturbed Permo-Carboniferous beds, and highly disturbed Carboniferous rock existing at most points, where the two formations are in contact. The serpentine has intruded the Burindi Carboniferous Series at Crow Mountain, and a pebble of serpentine occurs in the Permo-Carboniferous sandstones in the Newcastle district, as do also other rocks which have come from the north. The Jurassic sandstones lie horizontally and undisturbed, on the vertically dipping serpentine-mass near Warialda. The evidence for these statements will be detailed later. Unfortunately, the Permo-Carboniferous beds and serpentine occurring together *in situ,* are not clearly exposed, so that a direct proof in this manner is impossible

The gabbros and eucrites came slightly later than the serpentines. Their schistose structure suggests solidification during movement, while the dynamic type of metamorphism is indicative of the after-pressure they received by the later stages of the earth-folding.

Intruding the gabbros and serpentines, are a small series of dykes of dolerite, different from the earlier type of dolerite. They are common in the country north and south-east of Barraba, but have not been sought much elsewhere. In some mineralogical and structural variations, there are strong resemblances to certain of the lamprophyres of this region.

A third series of dolerites occur, the age and relationships of which cannot be told at present. They make large and small sills, and laccolites in the Barraba Series of rocks, in the region between Burindi Station, Horton and Cobbadah. Blue Knob laccolite is the larger of these. The manner of alteration suggests a Pre-Tertiary, probably a Pre-Mesozoic age, for these dolerites. Possibly they were intruded during the folding along an east and west axis, which seems to have followed the meridional crumpling. It may be that this movement was connected with that which lowered part of the Carboniferous range, admitting the deposition of Permo-Carboniferous sediments, in the lower series of which, are interstratified, hypersthene, andesite flows, in the Newcastle district. This relationship is, however, pure conjecture, there being little or no evidence on which to base any reasoning.

Following the main intrusions of basic igneous rocks, there occurs a long series of granitic intrusions, ranging probably from the latest Carboniferous to early Mesozoic times. The following grouping of these, based on the work of Andrews(**18**), Cotton(**16**), and others, must be regarded as tentative only.

Upper Carboniferous(?)—1.Felsites of Bingara.

Permian.—2.Granodiorites and Porphyries of Nundle.
3.Sphene-Granites of Moonbi.
4.Tingha Granite.

Early Mesozoic.—5.The "Acid Granite."
6.Tourmaline-granites east of Bingara and Manilla.

These masses of granite form a long series of intrusions lying *behind* the serpentine-intrusion, *i.e.,* in the direction from which the thrust came. In three places, however, the granite-rocks occur in front of the serpentine, namely, in the case of the Bingara felsites, and also in the large area of sphene-granite that has cut through the serpentine at Tamworth, and stretches between Moonbi and Attunga. Again, in the Nundle district, the whole area is seen to rest on a batholith of granite, which appears both east and west of the serpentine-belt.

The great and varied series of lamprophyre-dykes, which occur occur along the serpentine-belt, cannot be referred to any definite eruption-period as yet. Though they seem associated with the serpentine, it is difficult to understand their genetic relationship; it must be noted that the area between the serpentine and the granite, in the background, has not yet been thoroughly searched, and it is probable that evidence will be found there connecting the lamprophyres with the granites. In this connection, it is interesting to note that Mr. E. C. Andrews(17) has found a series of camptonites and other lamprophyres at Hillgrove, which lies on the eastern boundary of the intrusions of the sphene-granite period. He has shown these dyke-rocks to be, there, the latest phase of the igneous activity.

We now return to the consideration of the record of sedimentary rocks. The great earth-folding, which culminated in the intrusion of the peridotite, was a mountain-making period, but, nevertheless, in the closely following Permo-Carboniferous times, before the long series of granite-intrusions was at an end, sedimentation was again in progress. But of this we have very fragmentary evidence in the area under notice. Near Bowling Alley Point, a small block of a few acres only, in extent, has been faulted in among the Devonians, and thus preserved from denudation. The occurrence, in it, of *Glossopteris* leaves(6a) and Permo-Carboniferous marine shells, suggests that here is a portion of the Upper Marine series with some of the Upper Coal-Measures. Again, in the Nandewar Mountains, Dr. Jensen(9) has shown the presence of *Glossopteris* in coal-bearing Upper Coal-Measures, resting unconformably on Carboniferous conglomerates, while Stutchbury, in 1853, noted a coal-seam, and the leaf-bearing sandstone of Derra Gap, west of the Horton River(7). Thirty miles north-east of Warialda, is Ashford, where definite Lower Marine Beds and Lower Coal-Measures have been found(18) on, thence, the Permo-Carboniferous beds, in a highly disturbed condition, stretch east and north to Emmaville, Drake, Texas, and Warwick(19). These contain forms of both the Lower and Upper Marine, and, near Texas, boulders, claimed as belonging to the glacial series.

Following the Permo-Carboniferous period was an era of great crumpling, increasing in intensity in the northern areas. The Newcastle district is slightly folded and faulted; the Nundle district must have been highly faulted; but the area around Ashford, and to the north and east, has been highly folded indeed, so that the rocks have largely become slates. It is for this reason, that the

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Permo-Carboniferous Beds so long escaped notice. There was so little to distinguish them from the older palæozoic slates associated with them. No doubt, the series of Permian and early Mesozoic intrusions accompanied these foldings.

A long period of erosion followed, and the granite was laid bare. On it was deposited a series of arkoses, conglomerates, and sandstones, which occur in the neighbourhood of Warialda, overlying granite; rocks of the Eastern series, serpentine and Barraba mudstones. These sandstones, etc., are about 100 feet thick, and contain *Alethopteris*, *Phyllopteris*, and *Brachyphyllum*, and have been referred to the Jurassic period(6d). They are quite undisturbed or merely gently inclined. In the neighbourhood of Slaughterhouse Creek, they form the upper parts of the range, capped by basalt, and are probably rather thicker than at Warialda.

The Tertiary formations are largely volcanic, and, for the sake of completeness, a very brief résumé of Dr. Jensen's(9) work in the Nandewar district, together with other facts, may here be given. In early Tertiary or late Mesozoic times, there occurred crustal movements, throwing down the western part of the Nandewar region. This induced volcanic action, commencing with the intrusion of dolerite-sills into the Permo-Carboniferous strata, followed by:—

(*a*) Sill-like and laccolitic intrusions of syenite, accompanied by flows of phonolite, trachyte, and allied alkaline lavas.

(*b*) Alkaline andesites and more porphyry-sills.

(*c*) Basic porphyrite-dykes and basalt-flows, which lasted into Pliocene times.

In the Barraba region, an ancient, wide-spreading river-basin became greatly alluviated during the early part of these eruptions, and a considerable amount of trachytic tuff is contained in its leaf-bearing clays, which are of considerable thickness, and contain Eucalyptus; the upper layers include a bed of diatomaceous earth about 10 feet thick(22). These are covered by the great flows of basalt of the last igneous epoch. Elsewhere there are masses of basalt covering a greater or less thickness of leaf-bearing, Tertiary drift, auriferous or gem-bearing clays, sands, and gravels. Such occur at Bingara, and south of Keera, and are discussed in more detail later.

In the Nundle district also, the Tertiary period was one in which valleys were deeply cut, filled with auriferous drift, and flooded with basalt. Just outside the area of the present survey, it seems probable that this basalt was much intruded by sills of teschenitic dolerite, and basanite(13).

A great period of elevation and block-faulting closed the Tertiary period, and the present topography was thus initiated. This requires careful study, and will be discussed in a later chapter.

LIST OF REFERENCES CITED.

1. Anderson, W. A.—Ann. Rept. of Dept. of Mines N. S. Wales, 1888, pp.179-182.

2. Clarke, W. B.—Reports on the Goldfields of New South Wales, published in the Votes and Proceedinga of the Legislative Council. Papers relative to the Geological Survey of New South Wales, and also in Great Britain, Parliamentary Papers. Further Papers relative to the Discovery of Gold in Australia. Contracted titles of the several reports and references as under.
   (*a*) Report i., Geology of the Country between Marulan and Peel River.
   (*b*) Report ii., Hanging Rock Diggings : Geology.
   (*c*) Report iii., Dispersion of Gold in Australia.
   (*d*) Report v., Hanging Rock and Peel River Field : Conditions and Prospects.
   (*e*) Report viii., Western Slopes of New England : Structure.

N.S.W., Leg. Council.	Great Britain, Parl. Papers.
(*a*) 1852, ii., pp.463-467.	Aug.1853, pp.26-30.
(*b*) 1852, ii., pp.469-475.	Aug.1853, pp.30-35.
(*c*) 1852, ii., pp.477-482.	Aug.1853, pp.35-39.
(*d*) 1852, ii., pp.485-487.	Aug.1853, pp.40-42.
(*e*) 1853, i., pp.565-612.	Feb. 1854, pp.42-55.

3. David, T. W. E., and Pittmann, E. F.—"On the Palæozoic Radiolarian Rocks of New South Wales. Q.J.G.S., 1899, pp.16-37.

4. Jaquet, J. B.—Ann. Rept. of Dept. of Mines of New South Wales.

5. Odernheimer, F.—"On the Geology of a part of the Peel River District in Australia." Q.J.G.S., 1855, pp.399-402.

6. Stonier, G. A.—(*a*) Ann. Rept. Dept. Mines N. S. Wales, 1891, p.261; (*b*) *ibid.*, 1892, p.137; (*c*)*ibid.*, 1894,pp.131-137; (*d*)*ibid.*, 1895, pp.160, 168, 172.
7. Stutchbury, S.—Trimonthly Reports. Geology of Warrumbungle Mountains and Namoi River Districts (*a*) and Country between Nandewar Ranges and the Condamine River, (*b*)N.S.W., Leg. Council, Votes and Proc., 1853, ii., pp.467-473, 685-695. Great Britain, Parl. Papers. Further Papers relative to Gold in Australia. Feb. 1854, pp.13-17. Dec. 1854, pp.45-54.
8. Ulrich, G. H.—"Notes on the Geology of New South Wales and Queensland, made in 1842-43." Cited by W. B. Clarke, in "Sedimentary Formations of New South Wales." Fourth Edition, Appendix xii.
9. Jensen, H. I.—"The Geology of the Nandewar Mountains." Proc. Linn. Soc. N. S. Wales, 1907, pp.842-914.
10. Etheridge, R., Jun.—"The Corals of the Tamworth District." Rec. Geol. Surv. N. S. Wales, Vol. vi., p.151.
11. Hinde, G. J.—"The Radiolaria in the Devonian Rocks of New South Wales. Q.J.G.S., 1899, pp.39-63.
12. Jaquet, J. B., and Harper, L. F.—"The Iron-Ore Deposits of New South Wales." Memoir No.2, Geol. Survey of N. S. Wales, 1901, Chap.vi., and Map. Also, Ann. Rept. Dept. Mines.
13. Walkom, A. B., and Browne, W. R.—"The Geology of the Eruptive and Associated Rocks of Pokolbin, New South Wales." Journ. Proc. Roy. Soc. N. S. Wales, 1911, pp.379-407.
14. Benson, W. N.—"Spilite Lavas and Radiolarian Rocks in New South Wales." Geol. Mag., 1913, p.21.
15. ——————"A Preliminary Account of the Geology of Nundle District, near Tamworth, N.S.W." Report Aust. Assoc. Adv. Sci., Vol. xii., pp.100-106.
16. Steinmann, G.—" Die Geologische Bedeutung der Tiefseebildungen und der opiolischen Eruptiva." Geol. Beobachtungen in den Alpen, ii., xvi., pp.44-65, 1905.
17. Dewey, H., and Flett, J. S.—"British Pillow Lavas and the Rocks associated with them." Geol. Mag., 1911, pp.202-9 and 241-8.
18. Andrews, E. C.—"The Geology of the New England Plateau, with special reference to the Granites of Northern New England." Rec. Geol. Survey N. S. Wales, Vol. viii., pp.108-129.
19. Cotton, L. A.—"The Tin-Deposits of New South Wales. Part i. The Elsmere-Tingha District." Proc. Linn. Soc. N. S. Wales, 1909,p.733.
20. Andrews, E. C.—Report on the Hillgrove Gold Field. Mineral Resources. Geol. Survey of N. S. Wales, 1900, pp.16, 17, and 24. Also, "The Geology of the New England Plateau. Part iv." Rec. Geol. Survey N. S. Wales, Vol. viii., pp.227-229.

21. DAVID, T. W. E.—"The Geology of the Hunter River Coal-Measures." Memoir No.4. Geol. Surv. N. S. Wales. Also, PITTMANN, E. F., Records Geol. Surv. N. S. Wales, Vol. v., pp.26-30.

22. ANDREWS, E. C.—"Report on the Drake Gold and Copper Field." Mineral Resources, Geol. Surv. N. S. Wales, No.12, 1908, pp.3-11, and the authorities there cited.

23. PITTMANN, E. F.—Ann. Rept. Dept. of Mines N. S. Wales, 1881 (1882), p.142. Also, CARD, G. W., and DUN, W. S., "The Diatomaceous Earth Deposits of New South Wales." Rec. Geol. Surv. N. S. Wales, Vol. v., Pt.3, p.19.

24. BENSON, W. N.—"Preliminary Note on the Nepheline-bearing Rocks of the Liverpool and Mount Royal Ranges." Journ. Proc. Roy. Soc. N. S. Wales, 1911, pp.176-186.

EXPLANATION OF PLATES XX.-XXI.

Plate xx.

Geological Map of the Bingara and Tamworth District.

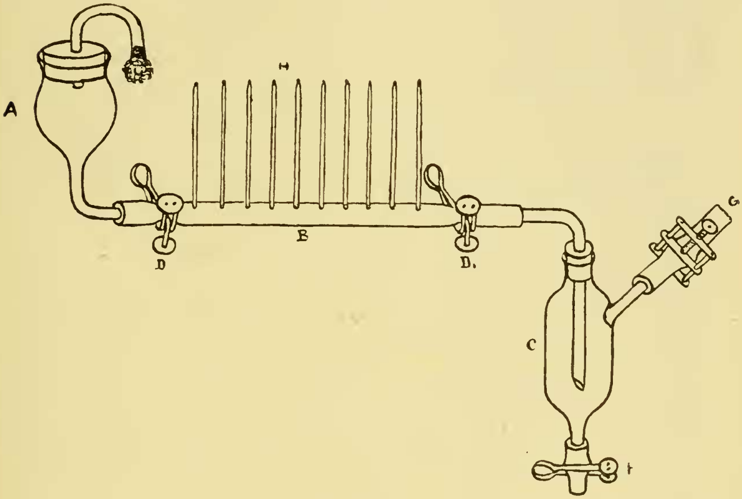
Plate xxi.

Geological Sections across the Bingara, Tamworth, and Nundle District.

NOTES AND EXHIBITS.

Mr. D. G. Stead reported that during a recent visit to the head-waters of the Jenolan River, within five miles of Jenolan, he had found Lyre-birds to be plentiful, and holding their own, in spite of the menace of the fox; and he considered that they may be expected to continue to do so, provided they are protected from being shot. Scrub-wallabies and wombats were also found to be plentiful; and from information received from residents, he had reason to think these interesting animals were on the increase; and it was to be hoped that they would not be unduly interfered with.

Mr. R. Grant showed, and explained the method of using a simple form of apparatus for the rapid filling of capillary tubes with calf-lymph, devised by Mr. A. B. Duffy and himself, and now in use in the Microbiological Laboratory of the Department of Health. With this apparatus, one person can easily fill over 600 capillary tubes in an hour, and all tubes are uniformly filled, —specimen-tubes. It can easily be made by any laboratory assistant, is very readily cleaned, and its cost is merely nominal. All that is required is a thistle-funnel, a piece of rubber pressure-tubing, with a series of holes pierced on the upper surface, three pinchcocks, a screw-clamp, and two or three pieces of glass tubing, one piece of which must be of fairly large calibre, with the ends drawn, and a side-tube blown into it. The method of filling tubes by means of the exhaust is—Fill funnel A with lymph. Open clamp D to allow a small flow of lymph to displace any air that may be caught in the tubing, between the funnel and the first capillary tube. As soon as the lymph is seen to ooze through the opening, close D. Insert the capillary tubes, the upper ends of which are sealed. Then start the exhaust, the screw-clamp controlling it being open. The exhaust is obtained by means of a Bunsen filter-pump attached to the service-pipe. It is very much handier than a hand-pump, and requires less attention. With the Bunsen pump, one merely has to turn on the water, and give an occasional glance at the pressure-gauge. It also enables the operator to devote the whole of his attention to the filling of the capillary tubes. With a properly constructed Bunsen pump, and a good pressure of water, a good exhaust can



Explanation of Figure.

A, Funnel or reservoir for holding the lymph—B, Rubber pressure-tubing, pierced in ten places on the upper surface, for holding the capillary tubes—C, Tube for catching overflow of lymph from tubing B—D, Clamp which controls the flow of lymph to capillary tubes—D_1, Clamp to control the exhaust—E, Rubber cork fitted with a piece of curved glass tubing, plugged with cotton-wool—F, Clamp: through this opening, the overflow lymph is withdrawn—G, Tube to exhaust, controlled by a screw-clamp—H, Capillary tubes.

be obtained in two or three minutes. When the manometer registers about 680 mm., open clamp D_1 for about 10 seconds, and then close it: next open clamp D: the lymph from A will now rush in, and fill all the capillary tubes to within $\frac{1}{8}$ inch of the ends. By keeping clamps D and D_1 both closed, the filled tubes can be removed, and replaced with fresh ones, and the operation repeated. After every filling, a small quantity of lymph remains in the rubber tubing B. This is removed, with every subsequent exhaustion, into tube C. When sufficient lymph has collected there, it can be readily withdrawn, and used over again by screwing down the clamp on tubing G, and opening clamps D_1 and F. Clamping tube G cuts off the exhaust and no capillary tubes must be placed in B. Filling the tubes by gravitation is very much simpler than the exhaustion-method. It is also much slower (the exhaustion is almost instantaneous), also open capillary tubes must be used. Fill up the funnel or reservoir A with lymph. Insert the capillary tubes. Keep clamp D_1 closed. Now open clamp D slowly. Watch the lymph rising in the tubes, close D as soon as it reaches to $\frac{1}{4}$ inch of the top of the tubes. With a portable peep-light, seal the end of each.

Mr. A. A. Hamilton exhibited some examples of Teratology, from the Collection of the National Herbarium, comprising *Rosa* Hort. var., Sydney Botanic Gardens(W. Challis; August, 1913), showing complicated prolification of the flower. The suppressed ovary is represented by an expansion of the flower-stalk, the sepals are leaf-like, the lower petals reflexed, the upper ones unaffected; the axis is prolonged, and bears a circlet of miniature roses, each with a leafy calyx; a few coloured petals, and foliar staminal and carpellary organs are present, the axis finally terminating in a tuft of leaves.—*Plantago lanceolata* Linn., Petersham(T. Steel; June, 1906), showing foliar prolification of the inflorescence, a tuft of leaves occurring on the apex of the flowering-spike, after the maturation of the fruit.—*Dodonæa peduncularis* Lindl., showing foliar prolification of the flower. An example of the male inflorescence of a diœcious plant, in which the calyx is normal, and the stamens replaced by a whorl of leaves.

Miss Hynes showed a specimen of *Coccoloba* (*Muehlenbeckia*) *platyclada* F.v.M., exhibiting xerophytic characters. When grown in a dry situation, the stems, as well as the branches, function as leaves.

Mr. W. W. Froggatt showed a series of specimens recently collected by him in the New Hebrides, comprising—a web-spinner, *Oligotoma* sp. [Fam. *Embiidæ*]; a handsome fruit-fly, *Dacus frenchi* Froggatt, a common orange-pest; and another fruit-fly(*Dacus* sp.) close to, if not identical with, the common melon-fly of India and Ceylon(*D. cucurbitæ* Coqu.), and destructive to melons in the Northern Territory of Australia. Also specimens of four species of Coconut leaf-mining beetles [Fam. *Hispidæ*], *Promecotheca opacicollis* from the New Hebrides, *P. antiqua* from the Solomon Islands, *P. reichei* from Fiji, and an undetermined species from Samoa; these beetles do an enormous amount of damage in the coconut plantations.

Mr. North, by the sanction of the Curator of the Australian Museum, sent for exhibition, the types of *Vini stepheni*, *Ptilopus insularis*, and *Porzana atra*, collected by Mr. A. E. Stephen, in 1907, at Henderson or Elizabeth Island, an outlier of the Paumoto Group or Low Archipelago, in the South Pacific, described by Mr. North in the Records of the Australian Museum, in the following year. Attention has recently been drawn to these species by Mr. W. R. Ogilvie Grant, in a paper in the July number of "The Ibis," in which he beautifully figures Stephen's Lorikeet, *Vini stepheni* (North).

DISCUSSION.

The discussion on "The Study of Zoogeographical Distribution by means of Specific Contours," introduced by Mr. R. J. Tillyard at the Meeting in May, was continued by Dr. J. B. Cleland. Mr. Tillyard reviewed, and replied to, the criticism of his proposals. The following is a summary of the discussion: (for Mr. Tillyard's introductory remarks, see pp.172-173).

Dr. Ferguson exhibited a typical Entogenic Contour, which he had obtained by Mr. Tillyard's method, for a well-defined group of Australian *Amycteridæ* [COLEOPTERA].

Dr. Cleland claimed that the chief, in fact, almost the only, factor in the determination of zoo-geographical distributions of groups was the tendency of species to mutate; and expressed the